

Performance Tuning PCIe® Systems

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Synopsys

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Agenda

- **Performance Tuning**
- **Replay Buffer**
- **Credits**
- **Posted Requests**
- **Non Posted Requests**
- **Performance Measurement**
- **Examples**

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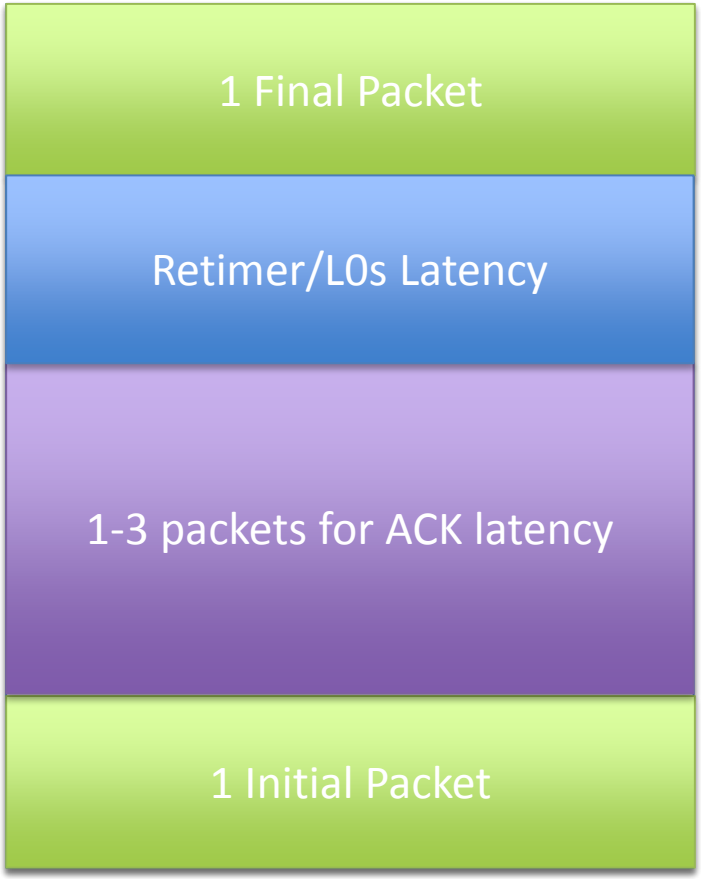
Performance Tuning

- **Link Width (x1-x16)**
- **Maximum Speed (2.5GT/s - 16 GT/s)**
- **Adjustments**
 - Replay Buffer Sizing
 - Credits
 - Tags and Payload/Request Sizes
- **Measurement**
 - Simulation Environment

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Retry Buffer Sizing

- **Stores TLPs Pending ACK**
- **Link Partner ACKS**
 - Required Limit on ACK Latency
- **Account for Latency**
 - Retimers
 - L0s exit
- **Implies RAM area**



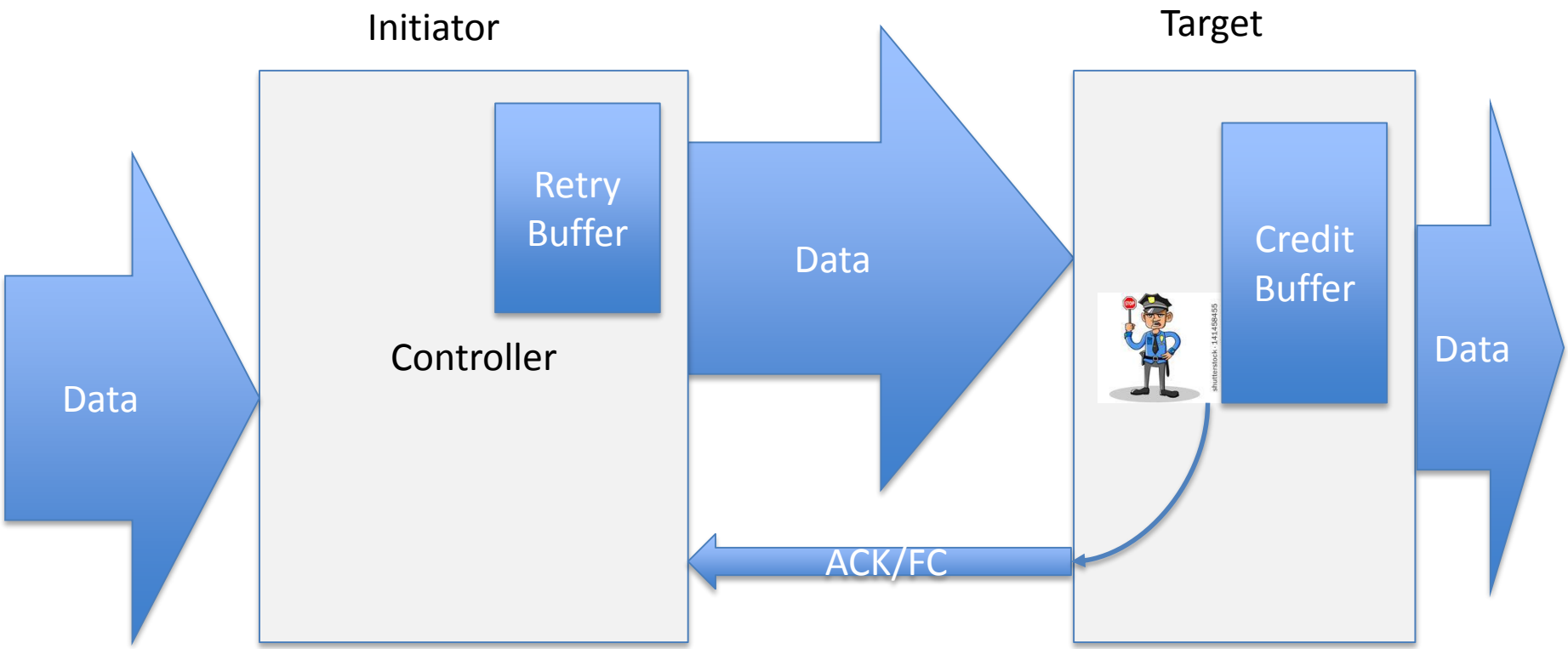
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Credit Advertisement

- **Defines ability of a receiver to sink data**
- **Data Credit**
 - Stream between FC updates
- **Header**
 - Stream small packets
- **Posted/Non-Posted/Completions**
 - Most Important: P data credits, NP header credits
 - Least Important: NP data credits
 - Infinite Completion Credits

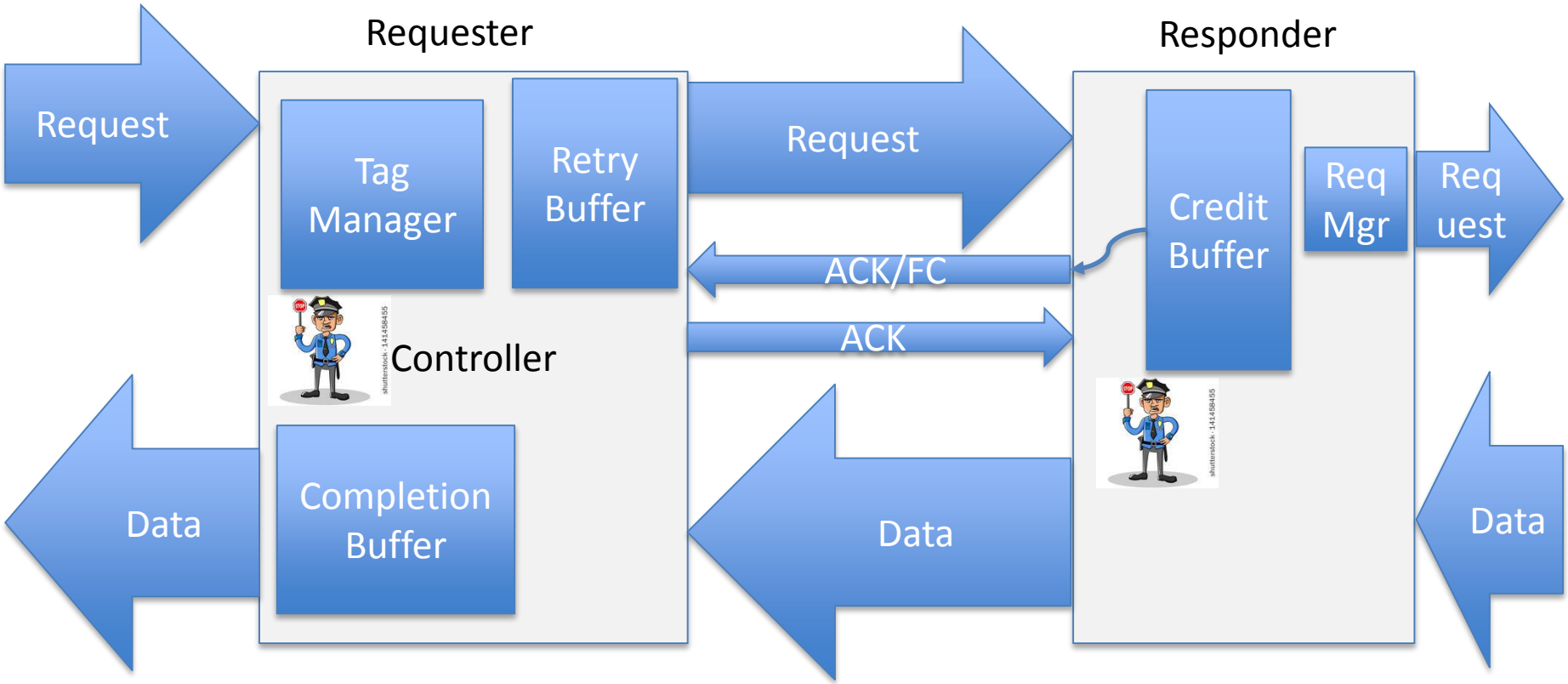
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Pushing Data (Posted Requests)



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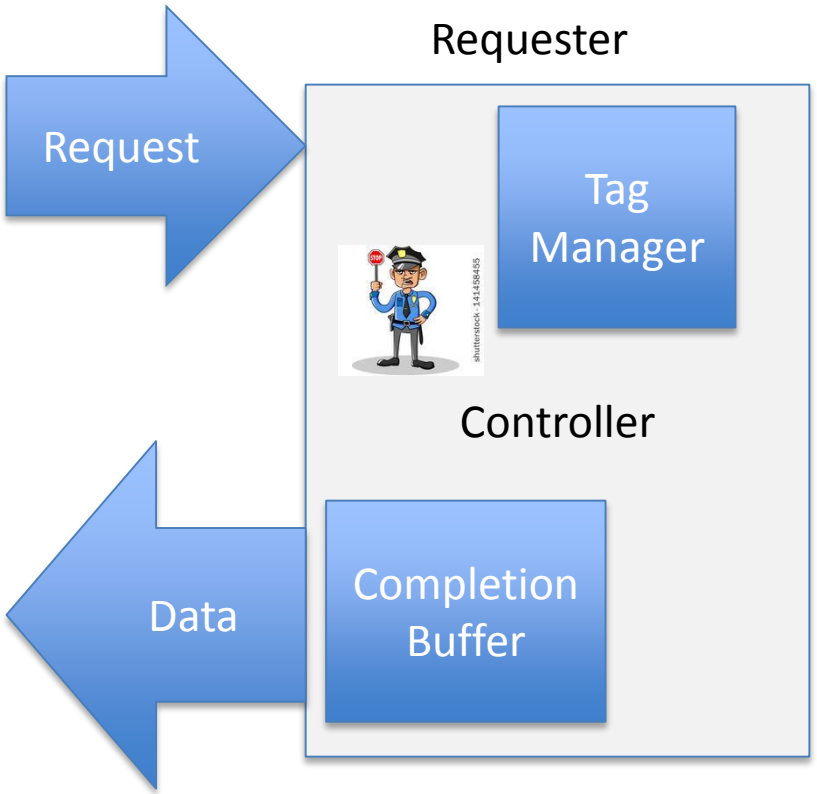
Pulling Data (NP Requests/Completions)



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NP Requests - Requester

- **Requester wants data**
- **Needs a tag to associate data with a request**
- **Each Tag consumes resources – tracking logic + storage**
- **More Tags == performance**



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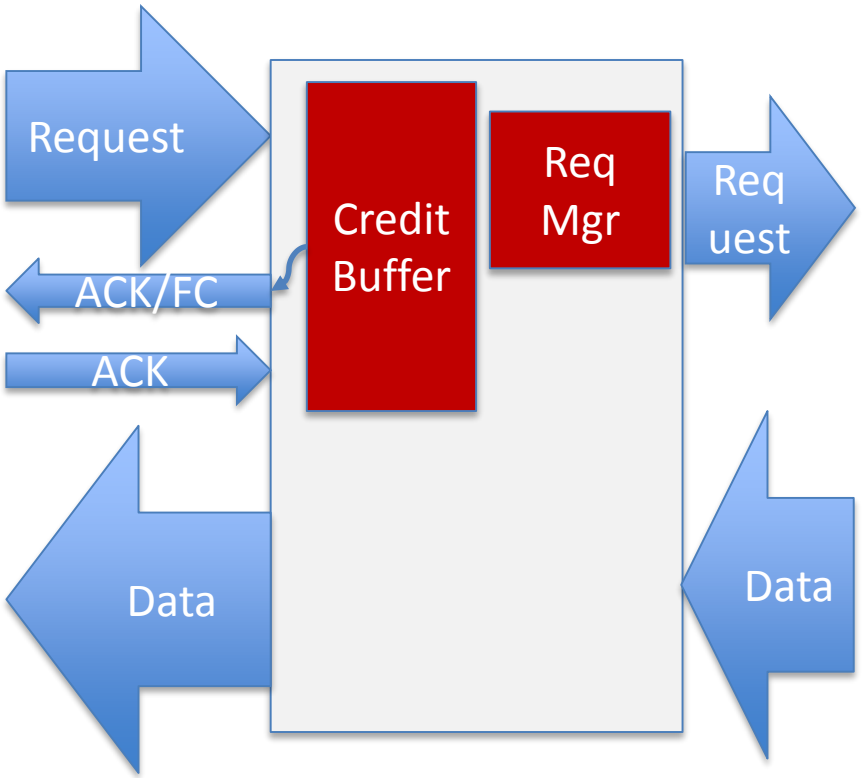
NP Requests – Transaction Sizes

- **Maximum Payload Size**
- **Maximum Read Request Size**
- **Multiple Completions**
- **Application Read Request Size**

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NP Requests - Responder

- **Responder Manages Inbound Requests**
- **How many outstanding Requests to Support?**
- **Consider the Expected Round Trip Time**
- **How many NP FC credits to advertise?**



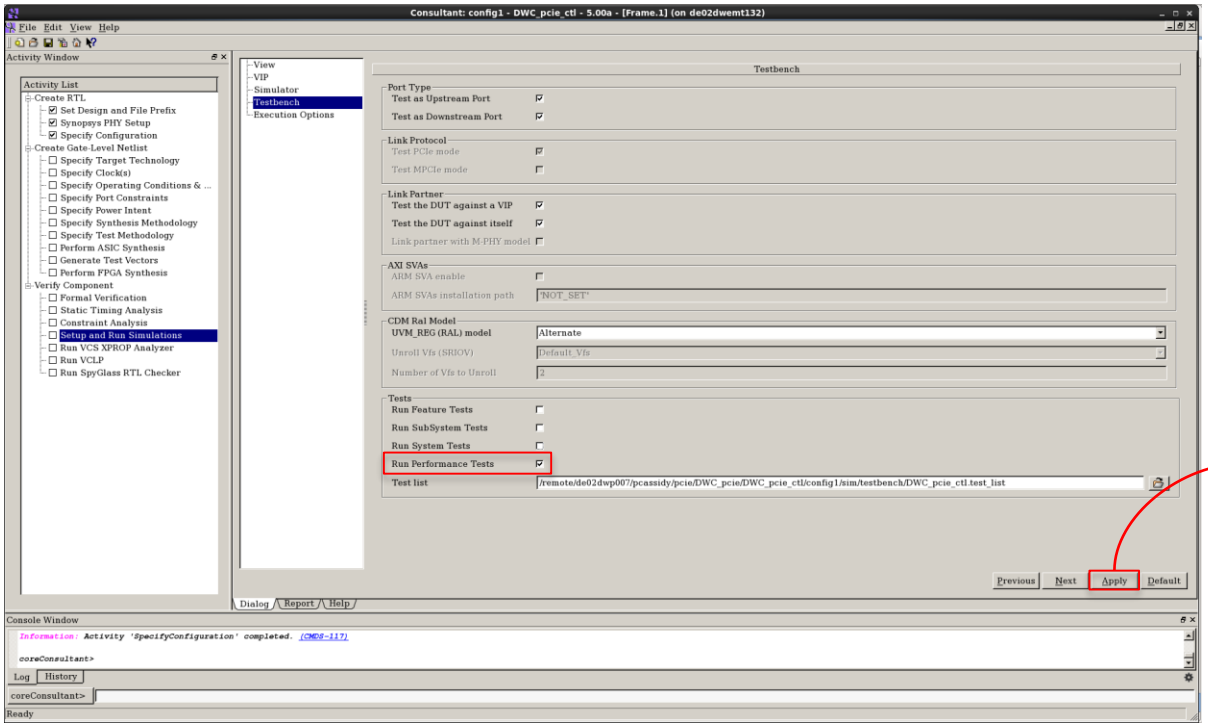
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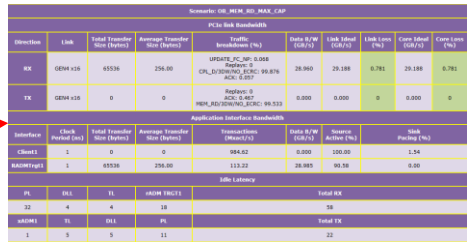
Performance Testing

- **A performance test suite allows trade offs to be analysed**
- **Real PHY model ensures FC/Ack Latencies are realistic**
- **Area vs. Performance decisions can be taken**

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Performance Test Suite





- **Allows Performance under various scenarios to be measured**

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Performance Test Suite

Scenario: OB_MEM_RD_MAX_CAP									
PCIe link Bandwidth									
Direction	**Link**	**Total Transfer Size (bytes)**	**Average Transfer Size (bytes)**	**Traffic breakdown (%)**	**Data B/W (GB/s)**	**Link Ideal (GB/s)**	**Link Loss (%)**	**Core Ideal (GB/s)**	**Core Loss (%)**
RX	GEN4 x16	65536	256.00	UPDATE_FC_NP: 0.068 Replays: 0 CPL_D/3DW/NO_ECRC: 99.876 ACK: 0.057	28.960	29.188	0.781	29.188	0.781
TX	GEN4 x16	0	0	Replays: 0 ACK: 0.467 MEM_RD/3DW/NO_ECRC: 99.533	0.000	0.000	0	0.000	0
Application Interface Bandwidth									
Interface	**Clock Period (ns)**	**Total Transfer Size (bytes)**	**Average Transfer Size (bytes)**	**Transactions (Mxact/s)**	**Data B/W (GB/s)**	**Source Active (%)**	**Sink Pacing (%)**		
Client1	1	0	0	984.62	0.000	100.00	1.54		
RADMTrgt1	1	65536	256.00	113.22	28.985	90.58	0.00		
Idle Latency									
PL	**DLL**	**TL**	**rADM TRGT1**	**Total RX**					
32	4	4	18	58					
xADM1	**TL**	**DLL**	**PL**	**Total TX**					
1	5	5	11	22					

- **Simulation Environment calculates performance for a given scenario**

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Example X4 Link 2 Tags

Scenario: OB_MEM_RD_MAX_CAP									
PCIe link Bandwidth									
Direction	**Link**	**Total Transfer Size (bytes)**	**Average Transfer Size (bytes)**	**Traffic breakdown (%)**	**Data B/W (GB/s)**	**Link Ideal (GB/s)**	**Link Loss (%)**	**Core Ideal (GB/s)**	**Core Loss (%)**
RX	GEN4 x4	1048576	256.00	UPDATE_FC_NP: 1.992 Replays: 0 UPDATE_FC_P: 0.005 CPL_D/3DW/NO_ECRC: 96.199 ACK: 1.805	4.726	7.028	32.755	7.028	32.755
TX	GEN4 x4	0	0	UPDATE_FC_NP: 0.049 Replays: 0 UPDATE_FC_P: 0.049 ACK: 16.637 MEM_RD/3DW/NO_ECRC: 83.266	0.000	0.000	0	0.000	0

Application Interface Bandwidth							
Interface	**Clock Period (ns)**	**Total Transfer Size (bytes)**	**Average Transfer Size (bytes)**	**Transactions (Mxact/s)**	**Data B/W (GB/s)**	**Source Active (%)**	**Sink Pacing (%)**
Client1	1	0	0	18.47	0.000	3.69	49.99
RADMCplBy	1	1048576	256.00	18.46	4.726	60.21	0.00

Idle Latency				
PL	**DLL**	**TL**	**rADM BYP**	**Total RX**
31	3	5	2	41
xADM1	**TL**	**DLL**	**PL**	**Total TX**
2	3	5	12	22

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Example X4 Link 128 Tags

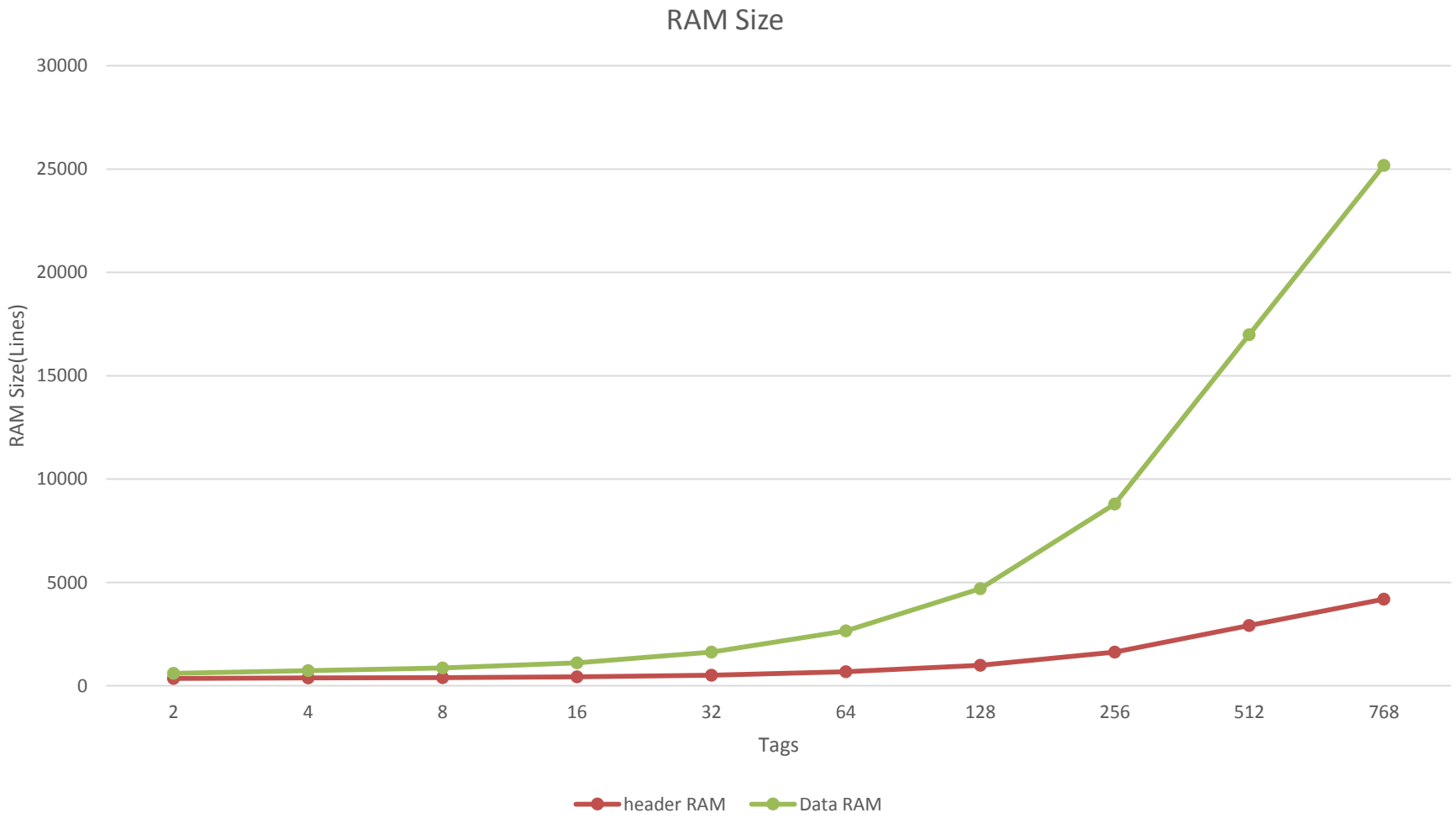
Scenario: OB_MEM_RD_MAX_CAP									
PCIe link Bandwidth									
Direction	**Link**	**Total Transfer Size (bytes)**	**Average Transfer Size (bytes)**	**Traffic breakdown (%)**	**Data B/W (GB/s)**	**Link Ideal (GB/s)**	**Link Loss (%)**	**Core Ideal (GB/s)**	**Core Loss (%)**
RX	GEN4 x4	1048576	256.00	UPDATE_FC_NP: 1.465 Replays: 0 UPDATE_FC_P: 0.003 CPL_D/3DW/NO_ECRC: 97.225 ACK: 1.308	7.074	7.103	0.408	7.103	0.408
TX	GEN4 x4	0	0	UPDATE_FC_NP: 0.035 Replays: 0 UPDATE_FC_P: 0.035 ACK: 11.449 MEM_RD/3DW/NO_ECRC: 88.482	0.000	0.000	0	0.000	0

Application Interface Bandwidth							
Interface	**Clock Period (ns)**	**Total Transfer Size (bytes)**	**Average Transfer Size (bytes)**	**Transactions (Mxact/s)**	**Data B/W (GB/s)**	**Source Active (%)**	**Sink Pacing (%)**
RADMTrgt1	1	1048576	256.00	27.63	7.074	88.43	0.00
Client1	1	0	0	28.48	0.000	5.79	50.83

Idle Latency				
PL	**DLL**	**TL**	**rADM TRGT1**	**Total RX**
31	3	5	41	80
xADM1	**TL**	**DLL**	**PL**	**Total TX**
2	3	5	12	22

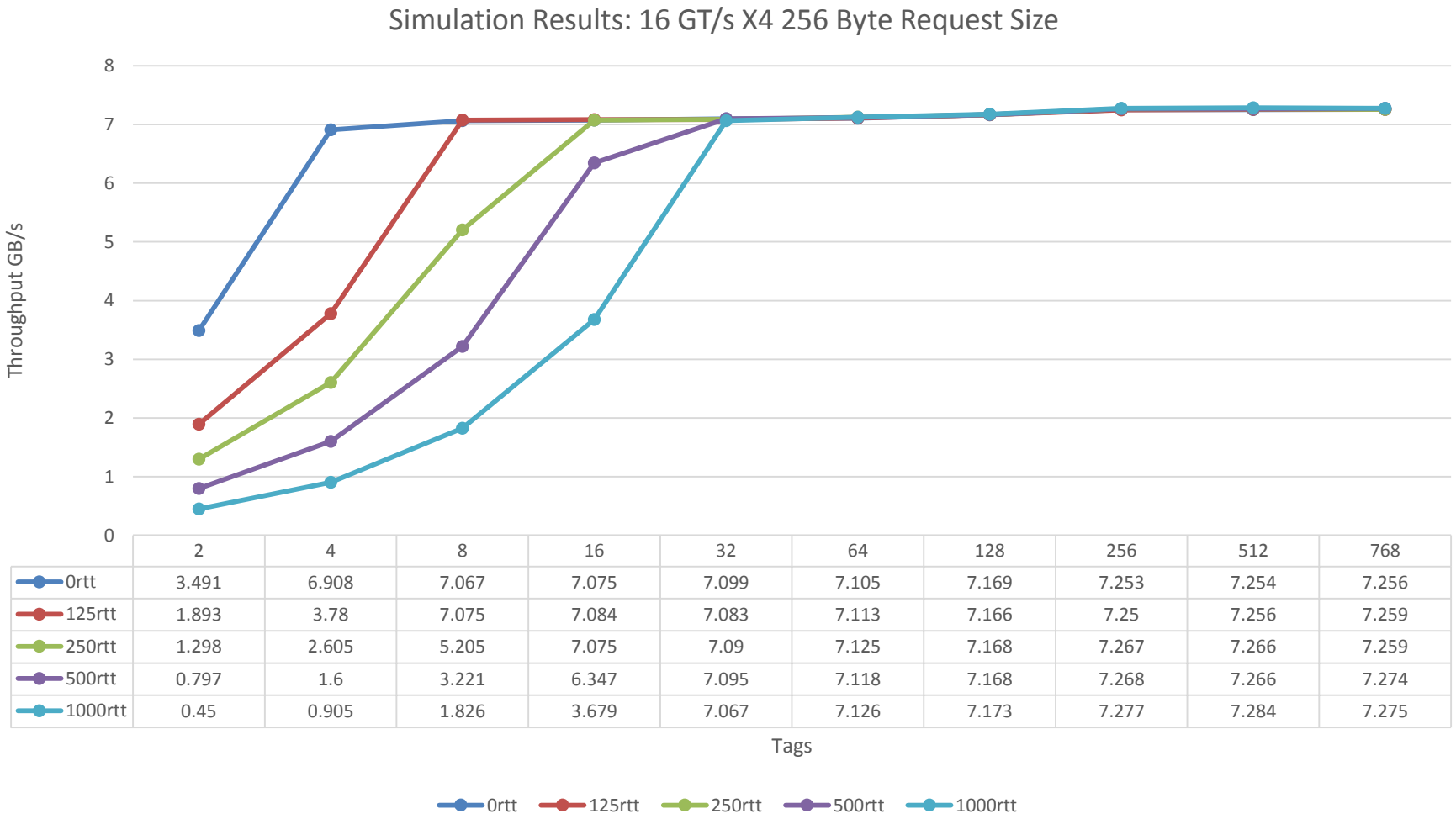
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RAM vs. Tags



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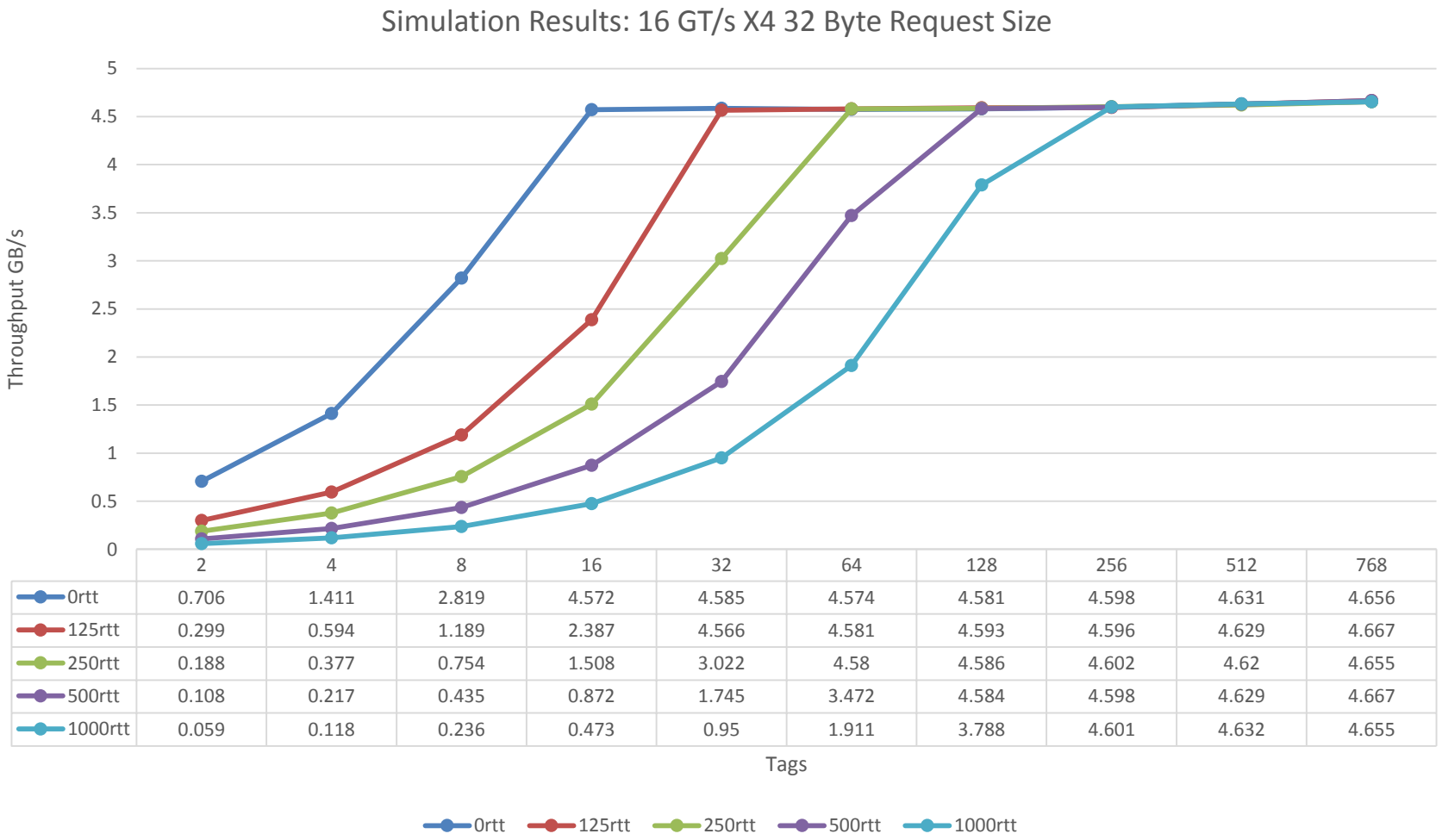
Tags vs. Performance X4



	2	4	8	16	32	64	128	256	512	768
0rtt	3.491	6.908	7.067	7.075	7.099	7.105	7.169	7.253	7.254	7.256
125rtt	1.893	3.78	7.075	7.084	7.083	7.113	7.166	7.25	7.256	7.259
250rtt	1.298	2.605	5.205	7.075	7.09	7.125	7.168	7.267	7.266	7.259
500rtt	0.797	1.6	3.221	6.347	7.095	7.118	7.168	7.268	7.266	7.274
1000rtt	0.45	0.905	1.826	3.679	7.067	7.126	7.173	7.277	7.284	7.275

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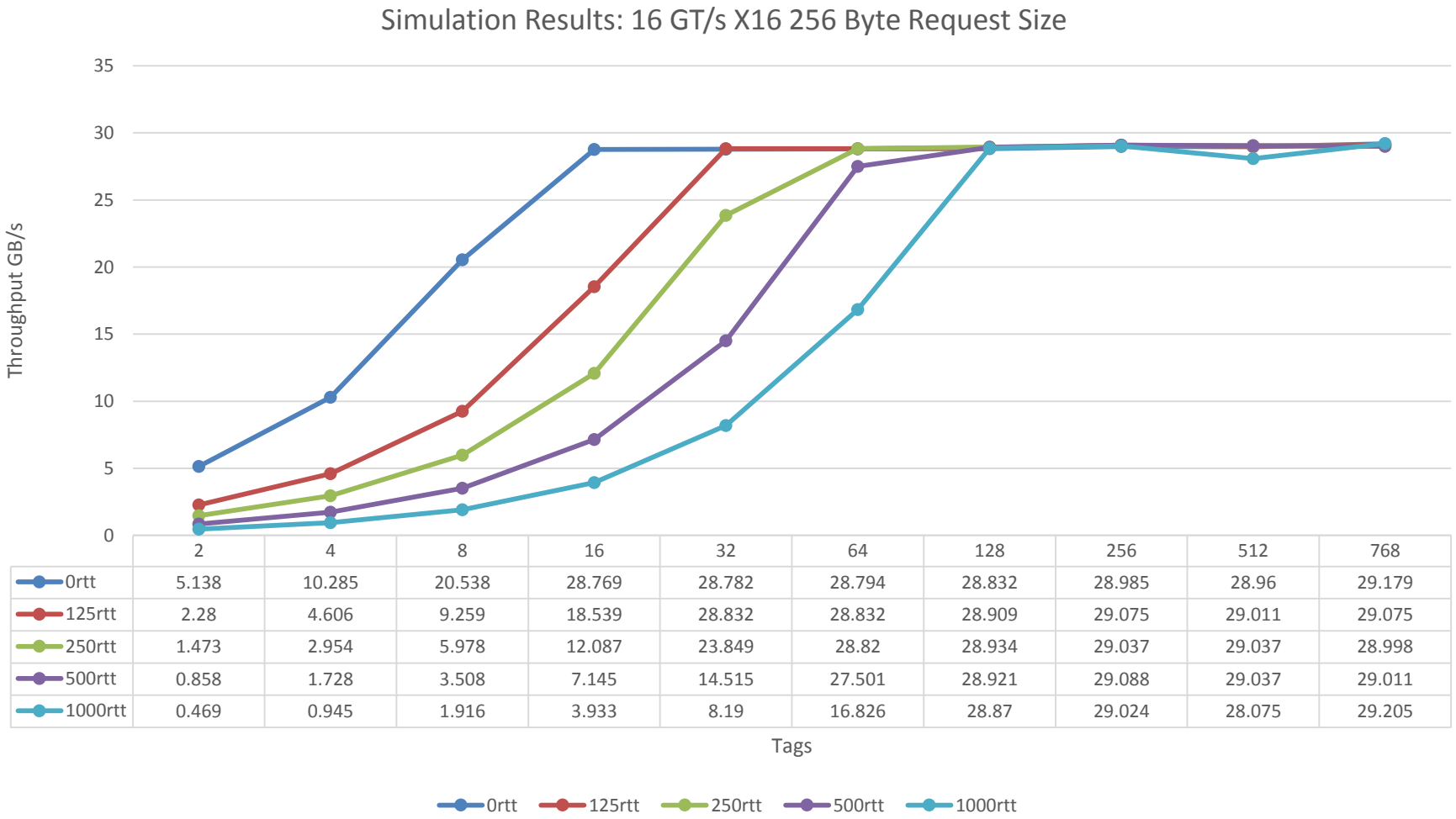
Tags vs. Performance X4



	2	4	8	16	32	64	128	256	512	768
0rtt	0.706	1.411	2.819	4.572	4.585	4.574	4.581	4.598	4.631	4.656
125rtt	0.299	0.594	1.189	2.387	4.566	4.581	4.593	4.596	4.629	4.667
250rtt	0.188	0.377	0.754	1.508	3.022	4.58	4.586	4.602	4.62	4.655
500rtt	0.108	0.217	0.435	0.872	1.745	3.472	4.584	4.598	4.629	4.667
1000rtt	0.059	0.118	0.236	0.473	0.95	1.911	3.788	4.601	4.632	4.655

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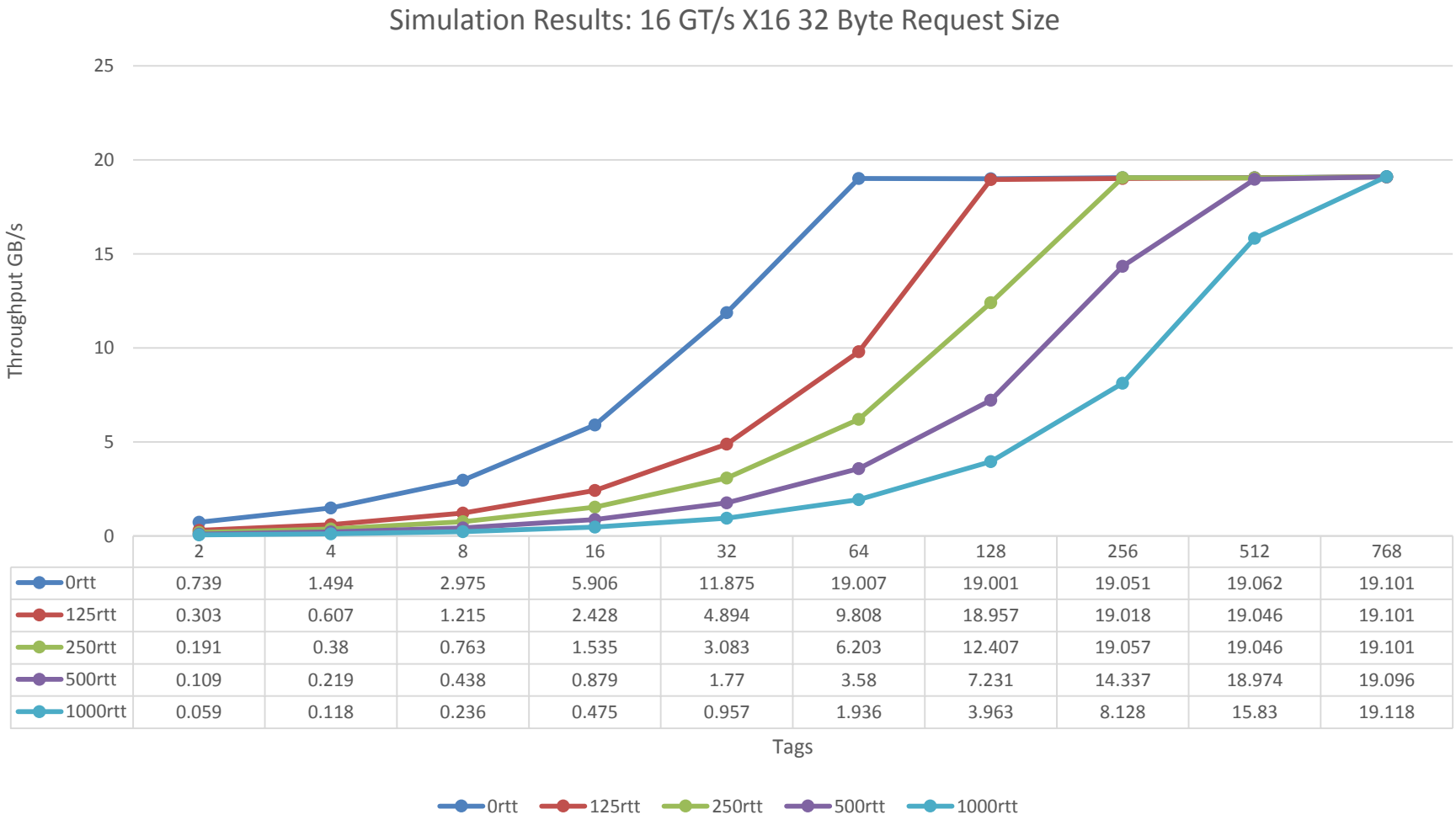
Tags vs. Performance X16



	2	4	8	16	32	64	128	256	512	768
0rtt	5.138	10.285	20.538	28.769	28.782	28.794	28.832	28.985	28.96	29.179
125rtt	2.28	4.606	9.259	18.539	28.832	28.832	28.909	29.075	29.011	29.075
250rtt	1.473	2.954	5.978	12.087	23.849	28.82	28.934	29.037	29.037	28.998
500rtt	0.858	1.728	3.508	7.145	14.515	27.501	28.921	29.088	29.037	29.011
1000rtt	0.469	0.945	1.916	3.933	8.19	16.826	28.87	29.024	28.075	29.205

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Tags vs. Performance X16



	2	4	8	16	32	64	128	256	512	768
0rtt	0.739	1.494	2.975	5.906	11.875	19.007	19.001	19.051	19.062	19.101
125rtt	0.303	0.607	1.215	2.428	4.894	9.808	18.957	19.018	19.046	19.101
250rtt	0.191	0.38	0.763	1.535	3.083	6.203	12.407	19.057	19.046	19.101
500rtt	0.109	0.219	0.438	0.879	1.77	3.58	7.231	14.337	18.974	19.096
1000rtt	0.059	0.118	0.236	0.475	0.957	1.936	3.963	8.128	15.83	19.118

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Summary

- **Trade Offs**
 - Look at number of credits advertised
 - Look at Tags in particular
 - Consider Round trip time
 - How much RAM/area can I afford

- **Use performance simulation to verify goals are met**

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